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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 687

Contribution from the States Relations Service
A. C. TRUE, Director.

Washington, D. C. PROFESSIONAL PAPER. June 28, 1918

DIGESTIBILITY OF SOME SEED OILS.[1]

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INTRODUCTION.

It was pointed out in the initial paper[2] of this series that while the information available regarding the digestibility of the various proteins and carbohydrates was quite extensive, much less attention had been given to the determination of the digestibility of the fats.

Not only is the information regarding the digestibility of edible fats limited but even when studies have been reported they were seldom made under uniform conditions which permit of comparison. Accordingly, this investigation was undertaken to obtain the coefficients of digestibility of a large number of the edible fats, under experimental conditions, as nearly as possible identical for all the fats studied.

Attention was first given to the animal fats, and the earlier papers[3] of this series contain reports of studies of the digestibility of lard, beef fat, mutton fat (kidney fats), butter, cream, and chicken, goose, egg yolk, brisket, and fish fats. The results indicate that all were well digested when eaten in amounts not in excess of those consumed in the ordinary dietary. More recent papers report studies of the digestibility of some of the better-known vegetable

[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.
[2] U. S. Dept. Agr. Bul. 310 (1915), pp. 22.
[3] U. S. Dept. Agr. Buls. 310 (1915), 507 (1917).

NOTE.—This bulletin records studies of the digestibility of corn oil, soy-bean oil, sunflower-seed oil, Japanese mustard-seed oil, rapseed oil, and charlock oil. It is primarily of interest to students and investigators of food problems.

fats, including olive, cottonseed, peanut, coconut, and sesame oils and cocoa butter,[1] and oils expressed from the following common nuts: Almond, black walnut, Brazil nut, butternut, English walnut, hickory nut, and pecan.[2] The results showed that when incorporated in a simple mixed diet these fats could be eaten in fairly large quantities without digestive disturbances and were very completely digested.

In continuation of these investigations this paper reports studies of the thoroughness of digestion of corn, soy-bean, sunflower-seed, Japanese mustard-seed, rapeseed, and charlock-seed oils. Edible corn oil has been on the market for a number of years, but the other oils of this group have been used in this country for food purposes in only a limited way as compared with olive, cottonseed, peanut, and coconut oils. However, all of these oils are so used in other countries and their oil-bearing seeds are produced to a greater or less extent in the United States.

For the purpose of this investigation good grades of corn, rape, and charlock oils were purchased in the open market. The sunflower oil (supplied by the Drug Plant Laboratories of the Bureau of Plant Industry) was expressed at a commercial mill from seed grown under known conditions. The mustard and soy-bean oils were expressed from first-quality seed in the laboratories of the Bureau of Chemistry. All of these oils were assumed to be representative of those ordinarily procured by the average consumer. In order that the oil of each kind studied should be of uniform composition, a quantity sufficient for the purpose of the investigation was obtained at the beginning of the experimental work and was thoroughly mixed before it was used for the test reported here.

EXPERIMENTAL METHODS.

The same experimental methods were employed in this investigation as in the studies previously reported, so that the coefficients of digestibility here reported should be directly comparable with those obtained for the fats already studied. The fat was incorporated in a cornstarch pudding or blancmange, which was heavily flavored with caramel to mask any characteristic flavor of the fat under consideration. A sufficient quantity of blancmange to supply all the subjects for the entire test was prepared at the beginning of the experimental period. It was very thoroughly mixed in order to insure uniform composition and a sample was reserved for analysis. This blancmange formed the principal part of a simple mixed diet, the foods eaten with it including wheat biscuits, oranges, and sugar,

[1] U. S. Dept. Agr. Bul. 505 (1917).
[2] U. S. Dept. Agr. Bul. 630 (1918).

with tea or coffee, if a beverage other than water was desired. Previous experiments have shown that such a diet is reasonably palatable and especially suited to a study of this character.

Other experimental conditions were the same as in the earlier digestion experiments with fats in which a 3-day or 9-meal test period proved entirely satisfactory, since it allowed the use of sufficient quantities of fat to give accurate results but was not so long that the diet became too monotonous. The test period was generally followed by a rest period of 4 days, during which the subjects were permitted to follow their usual dietary routine. The subjects of the digestion experiments were medical or dental students from 20 to 40 years of age, moderately active, of good health, and normal appetites. With one or two exceptions they had served as subjects of experiments previously reported, and in every instance were trustworthy and carried out carefully the directions given them. The diet during the experimental periods was limited to the prescribed ration and the subjects were instructed to reserve all uneaten portions of the diet for reweighing, and to observe care in the separation and collection of the feces.

The total amounts of food eaten were recorded, as well as the weight of the feces, and samples of both food and feces were analyzed. From the amount and composition of food and feces the percentages of protein, fat, and carbohydrates digested were calculated. Although the subjects were not required to eat any specified amount of food, it was desired that the weight of fat consumed daily should approximate that eaten in the earlier experiments (about 100 grams per man per day) in order that it would be possible to compare the physiological action of like amounts of edible fats. In general, the greater part of the food served was eaten without comment, showing that it was acceptable to the subjects. Though no special effort was made to determine the limit of tolerance of any of the fats under consideration the tests furnish data regarding it.

CORN OIL.

In the commercial manufacture of cornstarch and other corn products the germ is removed from the corn and remains as a by-product. When subjected to pressure the germ, which is more than half fat, yields an oil which has been used for some time for technical and also for culinary purposes. In a review of the present commercial production of corn oil Bailey[1] says that, as a result of the perfection of the methods of manufacture, and the careful separation of the germ, a very satisfactory edible oil is produced. Edible corn oil has been used quite extensively in the preparation of lard substitutes and it is now becoming quite a common household product.

[1] U. S. Dept. Agr., Yearbook Sept. 691.

In view of the very large amount of this oil that is produced annually, its value for edible purposes is a matter of very considerable interest. McPherson and Ruth[1] studied the possibility of the use of corn oil for shortening purposes and found that pastry made with mixtures of lard and corn oil in amounts not exceeding 10 per cent of the latter was identical in quality with pastry in which lard alone was used. Ritter[2] in a report of a study of the use of corn oil as a fat food in the treatment of tuberculosis states: "The ingestion of corn oil is well tolerated * * * and the prolonged and increasing dosage is always well borne by the stomach."

In the determination of the digestibility of a number of edible fats Moore[3] found that guinea pigs fed on wheat bran on which corn oil had been blown in a fine spray digested 86.47 per cent of the corn oil.

In order that the corn oil studied should be representative of corn oil as purchased by the average consumer two lots manufactured by different concerns were purchased on the open market at different seasons of the year. Both of these oils were stored under laboratory conditions for a time before being used for the tests here reported. Experiments Nos. 389, 390, 391, and 392 were made with one of the oils and experiments Nos. 689, 690, and 691 were made with the second oil. Since no marked differences were noted, it is to be assumed that the oils were very similar in their physiological action.

Seven experiments in which different subjects assisted are herewith reported, the data being summarized in the following tables:

Data of digestion experiments with corn oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 389, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing corn oil	1,983.0	901.1	37.1	247.3	786.2	11.3
Wheat biscuit	485.0	43.6	51.4	7.3	374.9	7.8
Fruit	831.0	722.1	6.6	1.7	96.4	4.2
Sugar	81.0	.....	.....	.....	81.0	.....
Total food consumed	3,380.0	1,666.8	95.1	256.3	1,338.5	23.3
Feces	94.0	.....	31.1	15.3	39.1	8.5
Amount utilized	.....	.....	64.0	241.0	1,299.4	14.8
Per cent utilized	.....	.....	67.3	94.0	97 1	63.5
Experiment No. 390, subject A. J. H.:						
Blancmange containing corn oil	2,571.0	1,168.3	48.1	320.6	1,019.4	14.6
Wheat biscuit	561.0	50.5	59.4	8.4	433.7	9.0
Fruit	1,406.0	1,221.8	11.3	2.8	163.1	7.0
Sugar	27.0	.....	.....	.....	27.0	.....
Total food consumed	4,565.0	2,440.6	118.8	331.8	1,643.2	30.6
Feces	101.0	.....	31.7	18.3	40.5	10.5
Amount utilized	.....	.....	87.1	313.5	1,602.7	20.1
Per cent utilized	.....	.....	73.3	94.5	97.5	65.7

[1] Ann. Rpt. Ohio Dairy and Food Comr., 21 (1906), pp. 18–23.

[2] Jour. Amer. Med. Assoc., 51 (1908), No. 1, pp. 39, 40.

[3] Arkansas Sta. Bul. 78 (1903), pp. 33–41.

Data of digestion experiments with corn oil in a simple mixed diet—Continued.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 391, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing corn oil	1,615.0	733.9	30.2	201.4	640.3	9.2
Wheat biscuit	234.0	21.1	24.8	3.5	180.9	3.7
Fruit	557.0	484.0	4.5	1.1	64.6	2.8
Sugar	49.0	.....	.....	.....	49.0	.....
Total food consumed	2,455.0	1,239.0	59.5	206.0	934.8	15.7
Feces	55.0	.....	18.3	12.5	18.1	6.1
Amount utilized	.....	.....	41.2	193.5	916.7	9.6
Per cent utilized	.....	.....	69.2	93.9	98.1	61.1
Experiment No. 392, subject O. E. S.:						
Blancmange containing corn oil	1,748.0	794.3	32.7	218.0	693.1	9.9
Wheat biscuit	356.0	32.1	37.7	5.3	275.2	5.7
Fruit	984.0	855.1	7.9	2.0	114.1	4.9
Sugar	181.0	.....	.....	.....	181.0	.....
Total food consumed	3,269.0	1,681.5	78.3	225.3	1,263.4	20.5
Feces	95.0	.....	31.2	13.5	39.2	11.1
Amount utilized	.....	.....	47.1	211.8	1,224.2	9.4
Per cent utilized	.....	.....	60.2	94.0	96.9	45.9
Experiment No. 689, subject P. K.:						
Blancmange containing corn oil	1,892.0	829.5	37.8	263.6	746.2	14.9
Wheat biscuit	318.0	28.6	33.7	4.8	245.8	5.1
Fruit	424.0	368.5	3.4	0.8	49.2	2.1
Sugar	156.0	.....	.....	.....	156.0	.....
Total food consumed	2,790.0	1,226.6	74.9	269.2	1,197.2	22.1
Feces	71.0	.....	22.5	13.8	28.1	6.6
Amount utilized	.....	.....	52.4	255.4	1,169.1	15.5
Per cent utilized	.....	.....	70.0	94.9	97.7	70.1
Experiment No. 690, subject A. A. R.:						
Blancmange containing corn oil	1,815.0	795.7	36.3	252.8	715.9	14.3
Wheat biscuit	131.0	11.8	13.9	2.0	101.2	2.1
Fruit	1,198.0	1,041.0	9.6	2.4	139.0	6.0
Sugar	124.0	.....	.....	.....	124.0	.....
Total food consumed	3,268.0	1,848.5	59.8	257.2	1,080.1	22.4
Feces	96.0	.....	36.6	14.2	37.3	7.9
Amount utilized	.....	.....	23.2	243.0	1,042.8	14.5
Per cent utilized	.....	.....	38.8	94.5	96.5	64.7
Experiment No. 691, subject W. E. T.:						
Blancmange containing corn oil	903.0	395.9	18.1	125.8	356.1	7.1
Wheat biscuit	270.0	24.3	28.6	4.1	208.7	4.3
Fruit	1,006.0	874.2	8.1	2.0	116.7	5.0
Sugar	209.0	.....	.....	.....	209.0	.....
Total food consumed	2,388.0	1,294.4	54.8	131.9	890.5	16.4
Feces	65.0	.....	20.7	15.1	22.2	7.0
Amount utilized	.....	.....	34.1	116.8	868.3	9.4
Per cent utilized	.....	.....	62.2	88.6	97.5	57.3
Average food consumed per subject per day	1,053.0	542.7	25.8	79.9	397.5	7.2

Summary of digestion experiments with corn oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
389	D. G. G	67.3	94.0	97.1	63.5
390	A. J. H	73.3	94.5	97.5	65.7
391	R. L. S	69.2	93.9	98.1	61.1
392	O. E. S	60.2	94.0	96.9	45.9
689	P. K	70.0	94.9	97.7	70.1
690	A. A. R	38.8	94.5	96.5	64.7
691	W. E. T	62.2	88.6	97.5	57.3
	Average	63.0	93.5	97.3	61.2

On an average the subjects ate 26 grams of protein, 80 grams of fat, and 398 grams of carbohydrates. The fuel value of the diet was 2,415 calories. The total fat of the diet, approximately 97 per cent of which was corn oil, was 93.5 per cent digested. When the usual correction for the undigested fat of the basal ration and metabolic products is made, the value 93.5 per cent for the digestibility of the total fat of the diet becomes 96.9 per cent for the digestibility of corn oil alone. In these as in all other tests, except those with charlock oil, the fat-rich blancmange was eaten readily and without comment, showing that the oil as used was not unpalatable. The proteins and carbohydrates supplied by the diet were 63 per cent and 97 per cent digested, respectively, values which correspond with those obtained for these constituents in earlier experiments of this series.

In the reports which the subjects submitted regarding their physical condition during the experimental periods, no reference was made to any laxative effect resulting from the diet. On the basis of the results of the tests reported it may be reasonably concluded that refined corn oil, when eaten in amounts comparable with the amount of fat occurring in the average dietary, served satisfactorily for food purposes.

SOY-BEAN OIL.

The soy bean (*Glycine soja*), prepared in a variety of ways, has long been a staple article of diet in the oriental countries, ranking very close to rice in order of importance. As a result of the long-continued use of this legume for food purposes, the oriental peoples have developed many special ways of using the protein and carbohydrate of the soy bean, some with and some without the oil. Though used for fuel and illuminating purposes in the Orient, much less attention seems to have been given to the dietary use of the separated soy-bean oil.

In the United States constantly increasing quantities of soy beans, imported from the Orient or produced for the most part in the cotton-growing districts, are pressed in the cottonseed-oil mills. The oil is largely used for technical purposes, especial attention having been given to its use as a paint oil. Work which has been done indicates that the characteristic odor and taste of the crude oil can be nearly, if not entirely, eliminated by careful refining and that the refined oil may be used for food purposes.

Korenchevsky and Zimmerman[1] made a study of the digestibility of soy-bean oil when eaten with a basal ration of rye bread, cabbage soup, and buckwheat or millet cooked as porridge. Three soldiers of normal health served as subjects and ate 100 grams of soy-bean

[1] Viestnik Obshch. Hig., Sudeb. i Prakt. Med., 1905, pp. 690–693.

oil daily, in addition to the 46 grams of fat supplied by the basal ration. The total fat of the diet was on the average 97 per cent digested. In a study of the digestibility of tofu (a soy-bean cheese), Oswa and Ueda [1] found the fat of the diet was 97.4 per cent digested. The fat eaten during this experiment was entirely supplied by the soy-bean tofu. In two experiments with a similar diet in which the tofu supplied all the fat eaten, Kano and Iishima [2] report that the fat was 95.3 per cent and 84.3 per cent digested respectively. Suchi [3] conducted an experiment to determine the digestibility of a diet of cooked rice and cooked tofu in which 93 per cent of the fat of the diet was furnished by the tofu and found that the fat was 96.5 per cent digested. On a diet consisting of rice, tofu, sugar, starch, and shoyu (soy sauce) in which 99 per cent of the total fat of the diet was furnished by tofu Osawa [4] found that the fat was 94.8 per cent digested.

Since some difficulty was experienced in securing soy-bean oil free from marked odor or taste, it was decided to express oil from cleaned mammoth yellow soy beans which had been grown under known conditions by the Bureau of Plant Industry. Through the courtesy of H. S. Bailey, oil specialist of the Bureau of Chemistry, the oil was expressed in a continuous process expeller type of oil press under conditions approximating quite closely those of the commercial oil mill. The cold-pressed oil obtained was filtered and used without any refining. It was incorporated in the usual cornstarch blancmange and served as a part of the experimental diet.

Seven experiments were made with soy-bean oil and the results which were obtained are reported in the following tables:

Data of digestion experiments with soy-bean oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 432, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing soy-bean oil	1,348.0	633.9	23.6	167.3	512.8	10.4
Wheat biscuit	300.0	27.0	31.8	4.5	231.9	4.8
Fruit	1,173.0	1,019.3	9.4	2.3	136.1	5.9
Sugar	188.0	.....	.....	.....	188.0	.....
Total food consumed	3,009.0	1,680.2	64.8	174.1	1,068.8	21.1
Feces	100.0	.....	32.3	11.3	48.7	7.7
Amount utilized	.....	.....	32.5	162.8	1,020.1	13.4
Per cent utilized	.....	.....	50.2	93.5	95.4	63.5

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 159 (1905), p. 150.

[2] U. S. Dept. Agr., Office Expt. Stas. Bul. 159 (1905), p. 172. [Gun-i Gakko Gyofu (Bul. Army Med. Col), Tokyo, 1899, No. 3, p. 101.]

[3] U. S. Dept. Agr. Office Expt. Stas. Bul. 159 (1905), p. 152 [Tokoy Igakukuwai Zashsi (Jour. Tokyo Med. Soc.), 2 (1888), pp. 457, 511.]

[4] U. S. Dept. Agr., Office Expt. Stas. Bul. 159 (1905), p. 154 [Chugai Iji Shimpo (Med. News, foreign and domestic), Tokyo, 1889, No. 211, p. 6.]

Data of digestion experiments with soy-bean oil in a simple mixed diet.—Contd.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 433, subject A. J. H.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing soy-bean oil	2,472.0	1,162.6	43.3	306.8	940.3	19.0
Wheat biscuit	138.0	12.4	14.6	2.1	106.7	2.2
Fruit	1,048.0	910.7	8.4	2.1	121.6	5.2
Sugar	159.0	.....	.....	.....	159.0	.....
Total food consumed	3,817.0	2,085.7	66.3	311.0	1,327.6	26.4
Feces	106.0	.....	35.2	23.6	37.2	10.0
Amount utilized	.....	.....	31.1	287.4	1,290.4	16.4
Per cent utilized	.....	.....	46.9	92.4	97.2	62.1
Experiment No. 434, subject R. L. S.:						
Blancmange containing soy-bean oil	1,682.0	791.1	29.4	208.7	639.8	13.0
Wheat biscuit	274.0	24.7	29.0	4.1	211.8	4.4
Fruit	571.0	496.2	4.6	1.1	66.2	2.9
Sugar	107.0	.....	.....	.....	107.0	.....
Total food consumed	2,634.0	1,312.0	63.0	213.9	1,024.8	20.3
Feces	82.0	.....	27.1	14.8	30.9	9.2
Amount utilized	.....	.....	35.9	199.1	993.9	11.1
Per cent utilized	.....	.....	57.0	93.1	97.0	54.7
Experiment No. 435, subject O. E. S.:						
Blancmange containing soy-bean oil	1,670.0	785.4	29.2	207.2	635.3	12.9
Wheat biscuit	220.0	19.8	23.3	3.3	170.1	3.5
Fruit	1,204.0	1,046.3	9.6	2.4	139.7	6.0
Sugar	203.0	.....	.....	.....	203.0	.....
Total food consumed	3,297.0	1,851.5	62.1	212.9	1,148.1	22.4
Feces	85.0	.....	29.4	14.9	32.7	8.0
Amount utilized	.....	.....	32.7	198.0	1,115.4	14.4
Per cent utilized	.....	.....	52.7	93.0	97.2	64.3
Experiment No. 440, subject D. G. G.:						
Blancmange containing soy-bean oil	1,398.0	649.8	26.1	214.0	494.9	13.2
Wheat biscuit	363.0	32.7	38.5	5.4	280.6	5.8
Fruit	903.0	784.7	7.2	1.8	104.8	4.5
Sugar	201.0	.....	.....	.....	201.0	.....
Total food consumed	2,865.0	1,467.2	71.8	221.2	1,081.3	23.5
Feces	88.0	.....	28.8	10.1	42.2	6.9
Amount utilized	.....	.....	43.0	211.1	1,039.1	16.6
Per cent utilized	.....	.....	59.9	95.4	96.1	70.6
Experiment No. 441, subject A. J. H.:						
Blancmange containing soy-bean oil	2,193.0	1,019.3	41.0	335.8	776.3	20.6
Wheat biscuit	93.0	8.4	9.8	1.4	71.9	1.5
Fruit	1,086.0	943.7	8.7	2.2	126.0	5.4
Sugar	84.0	.....	.....	.....	84.0	.....
Total food consumed	3,456.0	1,971.4	59.5	339.4	1,058.2	27.5
Feces	107.0	.....	41.9	23.0	30.9	11.2
Amount utilized	.....	.....	17.6	316.4	1,027.3	16.3
Per cent utilized	.....	.....	29.6	93.2	97.1	59.3
Experiment No. 442, subject O. E. S.:						
Blancmange containing soy-bean oil	1,539.0	715.3	28.8	235.6	544.8	14.5
Wheat biscuit	217.0	19.5	23.0	3.3	167.7	3.5
Fruit	1,007.0	875.1	8.1	2.0	116.8	5.0
Sugar	148.0	.....	.....	.....	148.0	.....
Total food consumed	2,911.0	1,609.9	59.9	240.9	977.3	23.0
Feces	60.0	.....	20.9	10.0	23.4	5.7
Amount utilized	.....	.....	39.0	230.9	953.9	17.3
Per cent utilized	.....	.....	65.1	95.8	97.6	75.2
Average food consumed per subject per day	1,047.1	570.4	21.3	81.6	366.0	7.8

Summary of digestion experiments with soy-bean oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
432	D. G. G	50.2	93.5	95.4	63.5
433	A. J. H	46.9	92.4	97.2	62.1
434	R. L. S	57.0	93.1	97.0	54.7
435	O. E. S	52.7	93.0	97.2	64.3
440	D. G. G	59.9	95.4	96.1	70.6
441	A. J. H	29.6	93.2	97.1	59.3
442	O. E. S	65.1	95.8	97.6	75.2
	Average	51.6	93.8	96.8	64.2

It is shown in the summary of the data reported above for the seven experiments with soy-bean oil that on an average the subjects ate 21 grams of protein, 82 grams of fat, and 366 grams of carbohydrates, and that coefficients of digestibility of these constituents supplied by the diet as a whole were for protein 51.6 per cent, for fat 93.8 per cent, and for carbohydrates 96.8 per cent. The fuel value of the diet was 2,285 calories.

The values obtained for the digestibility of total fat in the individual experiments agree fairly closely with one another, the majority being within 1 per cent of the average value 93.8 per cent.

In a series of experiments[1] in which the basal ration was eaten without the addition of fat it was found that the feces resulting contained a certain amount of ether-soluble material. When allowance is made in the above data for the ether extract of the feces not resulting from the soy-bean oil the value 93.5 per cent becomes 97.5 per cent for the digestibility of soy-bean oil alone.

Since the subjects reported no unusual physiological effects as a result of this diet, and in view of the very complete utilization of soy-bean oil by the body, it would seem that well-refined soy-bean oil should prove a satisfactory food, and could be used in the same manner and quantities as other oils commonly used in the diet.

SUNFLOWER-SEED OIL.

It is well known that the seeds of the sunflower (*Helianthus annuus*), when subjected to pressure, yield a light yellow oil having properties quite similar to those of the common vegetable oils. Sunflower-seed oil, which was used by American Indians for food purposes,[2] is now little used as a food oil in the United States, the probable reason being the demand for the seed for poultry feeding and the large supply of other better-known oils. In some of the

[1] U. S. Dept. Agr. Bul. 510 (1915), p. 17.

[2] Iroquois Foods and Food Preparation, Can. Dept. Mines, Geol. Survey, 86 (1916), p. 100.

European countries, however, this oil is quite extensively used and is an important constitutent of the dietary. According to Lewkowitsch[1] the sunflower is largely grown in southern Russia and the cold-pressed oil is used there for culinary purposes and for margarin manufacture.

As the production of sunflower seed in this country may be materially increased, and since no tests of the digestibility of this oil were found on record, the experiments here reported were made to determine the digestibility of sunflower-seed oil when eaten as a constituent of a uniform diet such as was served during the test periods with the edible fats previously studied.

The data of the digestion experiments with sunflower-seed oil are included in the following tables:

Data of digestion experiments with sunflower-seed oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 597, subject A. J. H.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing sunflower-seed oil	1,706.0	752.7	61.2	245.2	633.9	13.0
Wheat biscuit	266.0	23.9	28.2	4.0	205.6	4.3
Fruit	30.0	26.1	.2	.1	3.5	.1
Sugar	.....	.....	.....	.....	.....	.....
Total food consumed	2,002.0	802.7	89.6	249.3	843.0	17.4
Feces	64.0	.....	22.7	11.9	22.6	6.8
Amount utilized	.....	.....	66.9	237.4	820.4	10.6
Per cent utilized	.....	.....	74.7	95.2	97.3	60.9
Experiment No. 598, subject P. K.:						
Blancmange containing sunflower-seed oil	2,326.0	1,026.2	83.5	334.3	864.3	17.7
Wheat biscuit	365.0	32.9	38.7	5.5	282.1	5.8
Fruit	706.0	613.5	5.7	1.4	81.9	3.5
Sugar	202.0	.....	.....	.....	202.0	.....
Total food consumed	3,599.0	1,672.6	127.9	341.2	1,430.3	27.0
Feces	88.0	.....	24.3	24.0	33.5	6.2
Amount utilized	.....	.....	103.6	317.2	1,396.8	20.8
Per cent utilized	.....	.....	81.0	93.0	97.7	77.0
Experiment No. 599, subject J. C. M.:						
Blancmange containing sunflower-seed oil	1,578.0	696.2	56.6	226.8	586.4	12.0
Wheat biscuit	236.0	21.2	25.0	3.6	182.4	3.8
Fruit	972.0	844.7	7.8	1.9	112.7	4.9
Sugar	109.0	.....	.....	.....	109.0	.....
Total food consumed	2,895.0	1,562.1	89.4	232.3	990.5	20.7
Feces	61.0	.....	17.0	11.7	27.2	5.1
Amount utilized	.....	.....	72.4	220.6	963.3	15.6
Per cent utilized	.....	.....	81.0	95.0	97.3	75.4
Experiment No. 600, subject C. J. W.:						
Blancmange containing sunflower-seed oil	1,910.0	842.7	68.6	274.5	709.7	14.5
Wheat biscuit	308.0	27.7	32.7	4.6	238.1	4.9
Fruit	948.0	823.8	7.6	1.9	110.0	4.7
Sugar	118.0	.....	.....	.....	118.0	.....
Total food consumed	3,284.0	1,694.2	108.9	281.0	1,175.8	24.1
Feces	102.0	.....	31.9	22.8	36.9	10.4
Amount utilized	.....	.....	77.0	258.2	1,138.9	13.7
Per cent utilized	.....	.....	70.7	91.9	96.9	56.8
Average food consumed per subject per day	981.7	477.6	34.7	92.0	370.0	7.4

[1] Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan and Co., Limited, 1909, vol. 2, pp. 103–105.

Summary of digestion experiments with sunflower-seed oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
597	A. J. H.	74.7	95.2	97.3	60.9
598	P. K.	81.0	93.0	97.7	77.0
599	J. C. M.	81.0	95.0	97.3	75.4
600	C. J. W.	70.7	91.9	96.9	56.8
	Average	76.9	93.8	97.3	67.5

The data of the above experiments indicate that the subjects ate on an average 92 grams of fat daily during the test periods and that this was 93.8 per cent digested. Approximately 98 per cent of the total fat eaten, or 90 grams daily, was sunflower-seed oil. When allowance is made for the metabolic products and the unutilized fat resulting from the fat of the basal ration, the value 93.8 per cent obtained for the digestibility of the total fat of the diet becomes 96.5 per cent for the digestibility of sunflower oil alone.

The diet as a whole supplied 35 grams of protein, 92 grams of fat, and 370 grams of carbohydrates per man per day, the average fuel value being 2,450 calories.

The subjects reported that they were in normal physical condition throughout the experimental period which would indicate that the limit of tolerance for sunflower-seed oil is in excess of a consumption of 90 grams daily, and that this amount is well assimilated by the body.

JAPANESE MUSTARD-SEED OIL.

Commercial mustard-seed oil occurs as a by-product of the manufacture of mustard used for condimental purposes and was formerly obtained from the seeds of a variety of mustard plants or from a mixture of seeds of different varieties. As a result of the present unsettled commercial conditions, little if any of those varieties of mustard seed formerly used for condimental purposes is now imported into this country. In order to meet the demand for mustard the manufacturers have employed the yellow Japanese mustard seed to quite an extent, and as a consequence the amount of Japanese mustard-seed oil on the market has been very greatly increased.

The seeds of the Japanese mustard (*Brassica cernua*) when subjected to pressure yield a light, brownish-yellow oil, having much the same characteristics as the common edible oils, and while little used in this country for edible purposes, should be considered as of interest from the standpoint of an edible oil.

No reports of the determination of the digestibility of this oil were found in the literature consulted. The oil used in these experiments

was expressed in the laboratories of the Bureau of Chemistry from a good grade of cleaned mustard seed imported by that bureau. While it was expressed under laboratory rather than under commercial conditions, it was assumed to be quite similar to the commercial mustard-seed oil.

The results of the tests made with unrefined oil are summarized in the following tables:

Data of digestion experiments with Japanese mustard-seed oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 615, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing mustard-seed oil	2,267.0	1,254.8	69.4	264.1	504.2	174.5
Wheat biscuit	401.0	36.1	42.5	6.0	310.0	6.4
Fruit	661.0	574.4	5.3	1.3	76.7	3.3
Sugar	203.0	.....	.....	.....	203.0	.....
Total food consumed	3,532.0	1,865.3	117.2	271.4	1,093.9	184.2
Feces	87.0	.....	24.1	12.2	44.8	5.9
Amount utilized	.....	.....	93.1	259.2	1,049.1	178.3
Per cent utilized	.....	.....	79.4	95.5	95.9	96.8
Experiment No. 616, subject J. C. M.:						
Blancmange containing mustard-seed oil	1,842.0	1,019.5	56.4	214.6	409.7	141.8
Wheat biscuit	287.0	25.8	30.4	4.3	221.9	4.6
Fruit	1,099.0	955.0	8.8	2.2	127.5	5.5
Sugar	126.0	.....	.....	.....	126.0	.....
Total food consumed	3,354.0	2,000.3	95.6	221.1	885.1	151.9
Feces	101.0	.....	27.7	7.5	57.6	8.2
Amount utilized	.....	.....	67.9	213.6	827.5	143.7
Per cent utilized	.....	.....	71.0	96.6	93.5	94.6
Experiment No. 617, subject C. J. W.:						
Blancmange containing mustard-seed oil	2,001.0	1,107.6	61.2	233.1	445.0	154.1
Wheat biscuit	339.0	30.5	36.0	5.1	262.0	5.4
Fruit	943.0	819.5	7.5	1.9	109.4	4.7
Sugar	115.0	.....	.....	.....	115.0	.....
Total food consumed	3,398.0	1,957.6	104.7	240.1	931.4	164.2
Feces	124.0	.....	40.6	17.7	54.2	11.5
Amount utilized	.....	.....	64.1	222.4	877.2	152.7
Per cent utilized	.....	.....	61.2	92.6	94.2	93.0
Average food consumed per subject per day	1,142.7	647.0	35.3	81.4	323.4	55.6

Summary of digestion experiments with Japanese mustard-seed oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
615	P. K.	79.4	95.5	95.9	96.8
616	J. C. M.	71.0	96.6	93.5	94.6
617	C. J. W.	61.2	92.6	94.2	93.0
	Average	70.5	94.9	94.5	94.8

The average coefficient of digestibility of the total fat of the diet was found to be 94.9 per cent. While the subjects on an average ate only 81 grams of fat daily, over 97 per cent was mustard-seed oil and the value for the digestibility of the total fat is increased when allowance is made for the ether extract of the feces resulting from the basal diet to 95.8 per cent for the digestibility of mustard-seed oil alone.

No attempt was made to feed larger quantities of the oil in order to secure data in regard to the limit of tolerance of the body for mustard-seed oil. In two of the experiments, Nos. 615 and 616, the subjects reported a slight diarrhea, and so it would seem that the limit of tolerance for this oil was not much in excess of 87 grams daily, the amount of mustard oil eaten by one of the subjects. It is quite possible, however, that the limit of tolerance for highly refined oil might be greater than that of the unrefined oil which was used.

The protein and carbohydrates furnished by the diet were 71 per cent and 95 per cent digested, respectively, values which compare favorably with the thoroughness of digestion of these constituents usually found in earlier tests in which the same basal ration was eaten. As a whole the diet supplied 35 grams of protein, 81 grams of fat, and 323 grams of carbohydrates daily and had a fuel value of 2,160 calories.

RAPESEED OIL.

The refined rapeseed oil of commerce is of a pale yellow color, possesses a characteristic taste, and is prepared from the seeds of the rape plant (*Brassica napus*).

Though rapeseed oil is not produced in the United States to any extent for edible purposes, cold-pressed rapeseed oil is used in Europe and especially in India for food purposes. In a discussion of commercial rapeseed oil, Lewkowitsch[1] states that this oil, called "bread" oil, is largely used in England by bakers for greasing the ends of loaves of bread to prevent their sticking together when baked.

No records of any direct determinations of the digestibility of this oil have been found in the literature consulted. However, in a study of the comparative digestibility of a rice and tofu diet with and without rapeseed oil, Suchi[2] found that the total fat of the diets was 93.9 per cent and 96.5 per cent digested, respectively. The author, who served as the subject of the experiments, ate in the latter experiment approximately 58 grams of fat daily, this amount being

[1] Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan and Co., Limited, 1909, vol. 2, p. 205.

[2] U. S. Dept. Agr., Office Expt. Stas. Bul. 159 (1905), p. 153. [Tokyo Igakukwai Zasshi (Jour. Tokyo Med. Soc.), 2 (1888), pp. 457, 511.]

supplied by the rice and tofu, and in the former ate 126 grams of fat daily, of which 57 grams was rapeseed oil. Bertarelli[1] conducted a series of digestion experiments to determine the relative nutritive value of margarin and butter and included an experiment in which the subject ate an average of 910 grams of white bread, 250 grams of meat, and 61.6 grams of a mixture of olive and colza (or rapeseed) oils. He found the total fat of the diet to be 95.82 per cent digested.

The oil used in the experiments here reported was purchased in the open market and was taken to be representative of the edible rapeseed oil of commerce. The following tables contain the data obtained during the test periods with rapeseed oil:

Data of digestion experiments with rapeseed oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 629, subject A. F.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing rapeseed oil	2,380.0	1,575.6	90.7	262.0	274.9	176.8
Wheat biscuit	291.0	26.2	30.8	4.4	224.9	4.7
Fruit	880.0	764.7	7.0	1.8	102.1	4.4
Sugar	152.0	.....	.....	.....	152.0	.....
Total food consumed	3,703.0	2,366.5	128.5	268.2	753.9	185.9
Feces	59.0	.....	17.7	9.1	26.8	5.4
Amount utilized	.....	.....	110.8	259.1	727.1	180.5
Per cent utilized	.....	.....	86.2	96.6	96.4	97.1
Experiment No. 630, subject P. K.:						
Blancmange containing rapeseed oil	2,499.0	1,654.3	95.2	275.2	288.6	185.7
Wheat biscuit	364.0	32.8	38.6	5.4	281.4	5.8
Fruit	570.0	495.3	4.6	1.1	66.1	2.9
Sugar	198.0	.....	.....	.....	198.0	.....
Total food consumed	3,631.0	2,182.4	138.4	281.7	834.1	194.4
Feces	91.0	.....	27.3	11.4	46.3	6.0
Amount utilized	.....	.....	111.1	270.3	787.8	188.4
Per cent utilized	.....	.....	80.3	96.0	94.4	96.9
Experiment No. 631, subject J. C. M.:						
Blancmange containing rapeseed oil	1,759.0	1,164.4	67.0	193.7	203.2	130.7
Wheat biscuit	291.0	26.2	30.8	4.4	224.9	4.7
Fruit	971.0	843.8	7.8	1.9	112.6	4.9
Sugar	152.0	.....	.....	.....	152.0	.....
Total food consumed	3,173.0	2,034.4	105.6	200.0	692.7	140.3
Feces	69.0	.....	19.7	7.3	36.0	6.0
Amount utilized	.....	.....	85.9	192.7	656.7	134.3
Per cent utilized	.....	.....	81.3	96.4	94.8	95.7
Experiment No. 632, subject C. J. W.:						
Blancmange containing rapeseed oil	2,290.0	1,516.0	87.3	252.1	264.5	170.1
Wheat biscuit	420.0	37.8	44.5	6.3	324.7	6.7
Fruit	833.0	723.9	6.6	1.7	96.6	4.2
Sugar	98.0	.....	.....	.....	98.0	.....
Total food consumed	3,641.0	2,277.7	138.4	260.1	783.8	181.0
Feces	112.0	.....	36.4	16.3	51.0	8.3
Amount utilized	.....	.....	102.0	243.8	732.8	172.7
Per cent utilized	.....	.....	73.7	93.7	93.5	95.4
Average food consumed per subject per day	1,179.0	738.4	42.6	84.2	255.4	58.4

[1] Riv. Ig. e Sanit. Pub., 9 (1898), No. 15, pp. 570–579.

Summary of digestion experiments with rapeseed oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
629	A. F.	86.2	96.6	96.4	97.1
630	P. K.	80.3	96.0	94.4	96.9
631	J. C. M.	81.3	96.4	94.8	95.7
632	C. J. W.	73.7	93.7	93.5	95.4
	Average	80.4	95.7	94.8	96.3

During the test periods with rapeseed oil the subjects ate on an average 43 grams of protein, 84 grams of fat, and 255 grams of carbohydrates daily which were 80.4 per cent, 95.7 per cent, and 94.8 per cent digested, respectively. Less than 3 per cent of the total fat eaten was supplied by the basal ration and approximately 82 grams of rapeseed oil was eaten by each subject daily. When allowance is made for that portion of the ether extract of the feces which has been shown to consist of metabolic products and undigested fat resulting from the basal ration the value 95.7 per cent obtained for the digestibility of the total fat of the diet becomes 98.8 per cent for the digestibility of rapeseed oil alone.

In their reports of their physical condition during the test periods the subjects made no mention of any laxative effects resulting from the diet and accordingly it is assumed that the limit of tolerance for rapeseed oil is somewhat in excess of 84 grams, the average amount eaten daily by the subjects during the experiments here reported.

CHARLOCK OIL.

The charlock (*Brassica arvensis*) or wild mustard is rarely, if ever, cultivated in the United States, but in some localities it appears in the grainfields to such an extent that when the grain is thrashed large quantities of charlock seed are present in the grain.

When such grain is cleaned at the elevators wheat screenings or what is commonly referred to as "dockage" by the elevator men is obtained. These screenings ordinarily contain a wide variety of weed seeds, including charlock. The charlock is later separated from the other weed seeds by the feed dealers who buy the "dockage" to obtain the wild oats and other feed seed which it contains. It has been estimated that charlock seed is obtained in this way in sufficient quantities to warrant its use for commercial purposes.

Charlock seed, when subjected to pressure, yields an oil very similar in properties to some of the common edible oils, but has, when unrefined, a harsh, unpleasant taste. Bailey and Burnett[1] studied

[1] Jour. Indus. and Engin. Chem., 8 (1916), No. 5, p. 429.

the chemical and physical characteristics of charlock oil and state that it can be refined sufficiently to be edible but that at present it is largely used for industrial purposes.

In view of its close resemblance to rape and mustard-seed oils, and since a survey of the literature revealed no information in regard to its digestibility, it seemed desirable to determine the digestibility of this oil when eaten under conditions identical with those under which the other fats have been studied. A good grade of unrefined commercial charlock-seed oil believed to be representative of that ordinarily obtained by the consumer was purchased on the open market for use in the tests.

The following tables contain the results obtained during four test periods:

Data of digestion experiments with charlock oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of food.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 641, subject A. F.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing charlock oil	2,235.0	1,178.5	57.2	192.4	795.0	11.9
Wheat biscuit	318.0	28.6	33.7	4.8	245.8	5.1
Fruit	686.0	596.1	5.5	1.4	79.6	3.4
Sugar	193.0	.....	.....	.....	193.0	.....
Total food consumed	3,432.0	1,803.2	96.4	198.6	1,313.4	20.4
Feces	85.0	.....	24.6	12.5	38.3	9.6
Amount utilized	.....	.....	71.8	186.1	1,275.1	10.8
Per cent utilized	.....	.....	74.5	93.7	97.1	52.9
Experiment No. 642, subject P. K.:						
Blancmange containing charlock oil	2,082.0	1,097.8	53.3	179.3	740.6	11.0
Wheat biscuit	342.0	30.8	36.2	5.1	264.4	5.5
Fruit	276.0	239.8	2.2	0.6	32.0	1.4
Sugar	102.0	.....	.....	.....	102.0	.....
Total food consumed	2,802.0	1,368.4	91.7	185.0	1,139.0	17.9
Feces	65.0	.....	20.1	10.5	28.7	5.7
Amount utilized	.....	.....	71.6	174.5	1,110.3	12.2
Per cent utilized	.....	.....	78.1	94.3	97.5	68.2
Experiment No. 643, subject J. C. M.:						
Blancmange containing charlock oil	1,916.0	1,010.3	49.0	165.0	681.5	10.2
Wheat biscuit	309.0	27.8	32.8	4.6	238.9	4.9
Fruit	369.0	320.7	3.0	0.7	42.8	1.8
Sugar	154.0	.....	.....	.....	154.0	.....
Total food consumed	2,748.0	1,358.8	84.8	170.3	1,117.2	16.9
Feces	72.0	.....	18.5	6.3	41.8	5.4
Amount utilized	.....	.....	66.3	164.0	1,075.4	11.5
Per cent utilized	.....	.....	78.2	96.3	96.3	68.0
Experiment No. 644, subject A. A. R.:						
Blancmange containing charlock oil	1,809.0	953.9	46.3	155.7	643.5	9.6
Wheat biscuit	284.0	25.6	30.1	4.3	219.5	4.5
Fruit	871.0	756.9	7.0	1.7	101.0	4.4
Sugar	252.0	.....	.....	.....	252.0	.....
Total food consumed	3,216.0	1,736.4	83.4	161.7	1,216.0	18.5
Feces	96.0	.....	29.1	9.5	50.3	7.1
Amount utilized	.....	.....	54.3	152.2	1,165.7	11.4
Per cent utilized	.....	.....	65.1	94.1	95.9	61.6
Average food consumed per subject per day	1,016.5	522.2	29.7	59.6	398.8	6.1

Summary of digestion experiments with charlock oil in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent*
641	A. F.	74.5	93.7	97.1	52.9
642	P. K.	78.1	94.3	97.5	68.2
643	J. C. M.	78.2	96.3	96.3	68.0
644	A. A. R.	65.1	94.1	95.9	61.6
	Average	74.0	94.6	96.7	62.7

Because of its pronounced odor the charlock oil was not completely masked by the caramel and vanilla used in the cornstarch blancmange in which it was incorporated. Doubtless for this reason the amounts of charlock oil eaten were small, being only 60 grams per man per day on an average. Notwithstanding its odor the subjects reported no unusual effects as a result of the experimental diet and it may be assumed that unrefined charlock oil in amounts not exceeding 60 grams daily was well tolerated. An odorless refined oil would undoubtedly have been much more acceptable.

As a whole the diet supplied 30 grams of protein, 60 grams of fat (of which 58 grams was charlock oil), and 399 grams of carbohydrates and a fuel value of 2,255 calories.

The average values obtained for the digestibility of the protein, fat, and carbohydrates supplied by the total diet were 74 per cent, 94.6 per cent, and 96.7 per cent, respectively. Making allowance for the undigested fat resulting from the basal ration and for the metabolic products, the value 94.6 per cent for the digestibility of the total fat of the diet becomes 98.9 per cent for the digestibility of charlock oil alone, which would seem to indicate that this oil was very well assimilated by the body.

SUMMARY.

The investigations on the digestibility of the seed oils here reported include seven experiments each with corn and soy-bean oils and four experiments each with sunflower-seed, Japanese mustard-seed, rapeseed, and charlock-seed oils. In each case the oils were incorporated in a cornstarch blancmange and eaten in conjunction with a uniform basal ration which supplied 2 per cent of the total fat eaten. As a result of the uniformity of the experimental methods followed, the values obtained for the different oils permit of direct comparison with one another and with the values obtained for the digestibility of the animal and vegetable fats previously reported.

During the test period in which the oils under consideration constituted practically the entire source of fat, the subjects ate on an

average 82 grams of corn oil, 80 grams of soy-bean oil, 90 grams of sunflower-seed oil, 79 grams of Japanese mustard-seed oil, 82 grams of rapeseed oil, and 58 grams of charlock oil per person per day.

After allowance had been made for the metabolic products and undigested fat resulting from the basal ration, the coefficients of digestibility were found to be—for corn oil, 96.8 per cent; for soy-bean oil, 97.5 per cent; for sunflower-seed oil, 96.5 per cent; for Japanese mustard-seed oil, 98.8 per cent; for rapeseed oil, 98.9 per cent, and for charlock oil, 98.9 per cent. These values agree well with one another and with the values obtained with other vegetable oils in tests previously reported.

No attempt was made to determine the limit of tolerance of the fats, but inasmuch as the subjects did not report any physiological disturbances as a result of eating these oils, except in experiments Nos. 615 and 616 with unrefined Japanese mustard-seed oil when a slight diarrhea was reported, it would appear that the limit of tolerance for the oils was somewhat in excess of the amounts eaten.

The carbohydrate eaten during these digestion experiments consisted largely of cornstarch, which was used as an ingredient of the blancmange, of sugar eaten both separately and as an ingredient of the blancmange, and of the carbohydrate which was supplied by the wheat biscuit. The coefficients of digestibility of the carbohydrate were 97 per cent in the corn-oil tests, 97 per cent in the soy-bean-oil tests, 97 per cent in the sunflower-seed-oil tests, 95 per cent in the Japanese mustard-seed-oil tests, 95 per cent in the rapeseed-oil tests, and 97 per cent in the charlock-seed-oil tests, which indicates that the oils under consideration exerted no unusual effect on the digestibility of carbohydrates.

Considering the results of the digestion experiments as a whole it is evident that corn, soy-bean, sunflower-seed, mustard-seed, rapeseed, and charlock-seed oils are well assimilated and judged by their digestibility should prove satisfactory sources of fat for the dietary.

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